Advanced Direct Methanol Fuel Cell for Mobile Computing

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Project ID
H2RA004

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Overview

Timeline

- Start date: January 1, 2010
- End date: December 31, 2011
- Percent complete: 60%

Barriers

Characteristic	Requirement
Specific Power	100 W/kg
Energy Density	1000 Wh/L
Cost	< $3/W at the system level
Lifetime	2000 hours

Budget

- Total project budget $3,056,988
  - DOE share $2,443,441
  - Contractor share $613,547
- DOE funding obligated in full in FY 2009

Partners

- University of Florida (UF)

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Relevance: Objective

- The project objective is to develop a DMFC power supply for mobile computing using the UNF novel passive water recycling technology which enables significant simplification of DMFC systems.
  - The objective of the 2011 effort to date is to perform system engineering and extensive brassboard (unpackaged) testing to move towards the 2010 Technical Targets.
  - The remainder of the project will focus on optimizing the performance of the packaged system.

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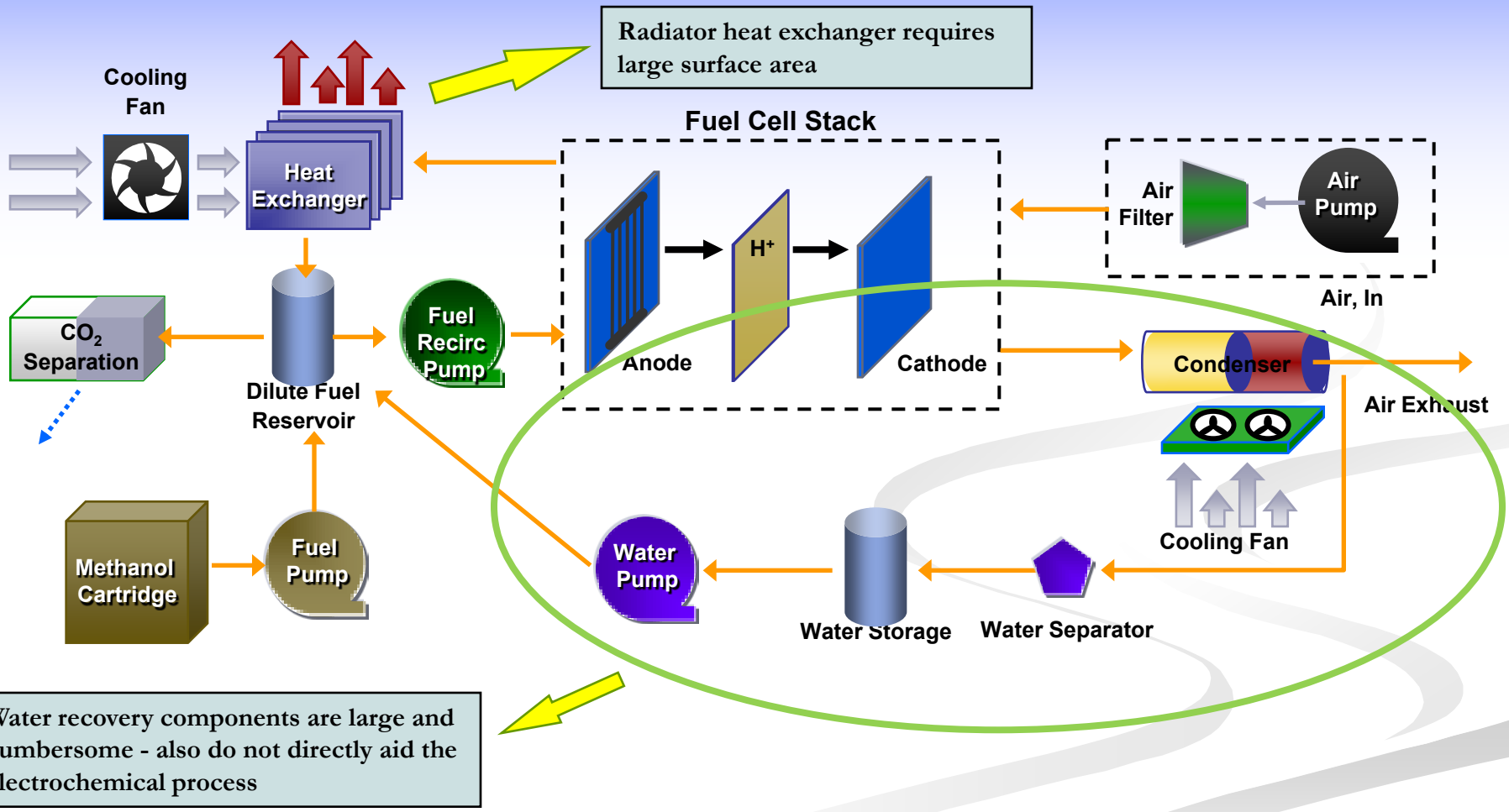
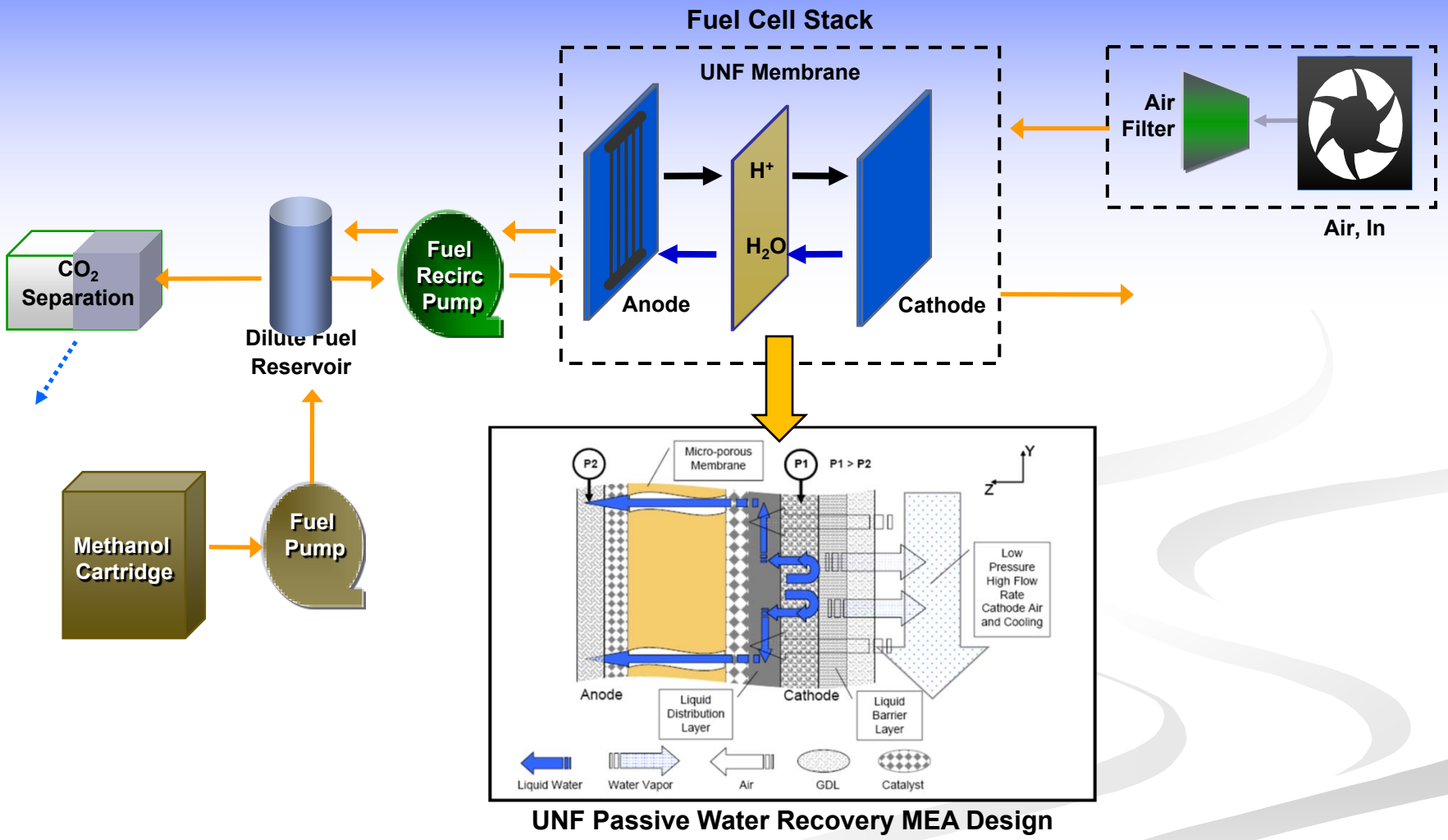
Relevance: Conventional DMFC System



Relevance: UNF's Simplified DMFC System



UNF Passive Water Recovery MEA Design

Novel passive water recovery MEA significantly reduces the number of balance of plant components

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Relevance: Impact

- UNF Baseline Membrane Electrode Assembly (MEA) provides path to system simplification and increased power and energy density, with lower system cost.

Characteristic	Units	UNF 15 W DP3 2008 Status	DOE 2010 Target	UNF Proposed 20W System Design
Specific Power [a]	W / kg	35	100	41.5
Power Density [a]	W / L	48	100	55 .6
Energy Density	W-hr / L	250 (1 x 100ml)[b] 396 (1 x 200ml)[b]	1000	193 (1 x 100ml) 321 (1 x 200ml) 575 (3 x 200 ml)
	W-hr/kg	155 (1 x 100ml) [b] 247 (1 x 200ml) [b]	N/A	162 (1 x 100 ml) 307 (1 x 200 ml) 638 (3 x 200 ml)
Lifetime [c]	Operating Hours	1,000 hrs in single cell	5,000	2,500 Integrated System
Cost	$ / Watt	11 (est. in volume)	<3	< 10 (est. in volume)

[a] Beginning of life, 30°C, sea level,50% R.H., excluding hybrid battery, power module alone
[b] Normalized from DP3 data from 150 ml cartridge to either 100ml or 200ml for comparison purposes
[c] Lifetime measured to 80% of rated power

Marked improvement on the road towards commercialization.

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Approach: Project Integration

- This project is focused on the balance of plant (pumps, blowers, sensors, etc.) development and overall system integration.
- This effort is highly integrated with the UNF-led Topic 5A: *New MEA Materials for Improved DMFC Performance, Durability, and Cost* project (DOE funded) which focuses on optimizing the passive water recovery MEA
  - Reducing off-state degradation.
  - Industry partner Johnson Matthey is applying commercial processes to the MEA production
  - Research partner Northeastern University is developing ultra-stable catalyst.
  - Critical to achieving cost, robustness, and lifetime goals for the DMFC power supply

Integrating the commercially produced MEA into the improved balance of plant is an important step towards commercialization.

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Approach: Milestones

90% Complete

➢Component Engineering
- CDRs Revised
- Component DFMEAs
- Key Subsystems – Prototypes
- Shell Body and Interface Prototypes
- Fuel Cartridge Prototype

70% Complete

➢Component/Subassembly Testing
- Component Performance & Durability
- Integrated Subsystem Testing

60% Complete

➢System Engineering
- Concept Design
- DFMEA, DFMA of System
- Brassboard Assembly & Testing
- System Assembly & Testing

60% Complete

➢Control System Development
- Rest /Rejuvenation Protocol Optimization
- Start-up & Shut-down Protocol
- Operating Protocol Tuning Revised System

40% Complete

➢System Validation Testing
- Test Plan Released
- Operating and Storage Durability Testing
- Ex-Situ System Testing
- In-Situ System Testing

➢Program Management
- Quarterly & Annual Report
- **Go /No-Go Decision point**

The project is on schedule. Go/No-Go Milestone review occurred in January.

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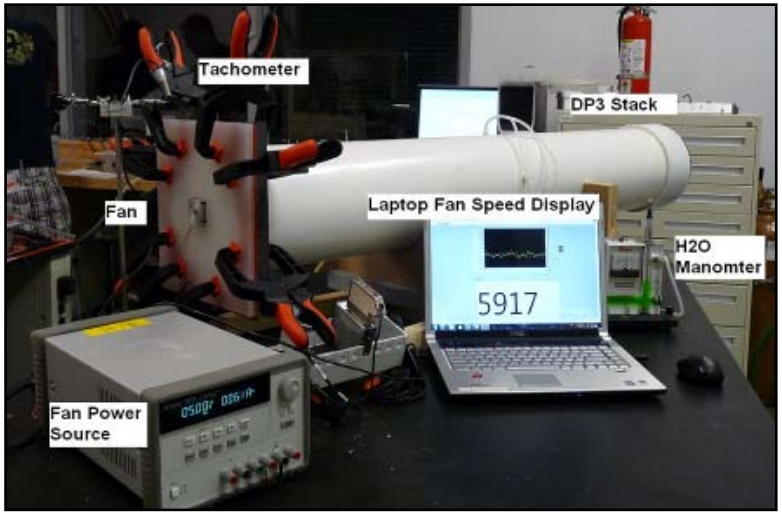
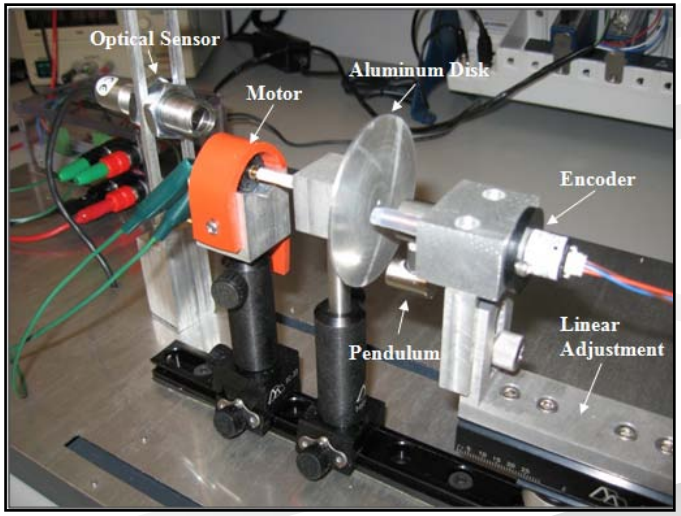
Technical Accomplishments:

Component Engineering

- CDRs have been defined and have been completed.
- Extensive testing of a multitude of available hardware and designs have been completed
- Candidate components and designs have been selected and incorporated into the brassboard system



Cooling Fan Test Stand: Used to measure the performance and efficiency of cathode fans.



Electric Motor Dyno: Used to measure the performance and efficiency of electric motors for pumps and fans.

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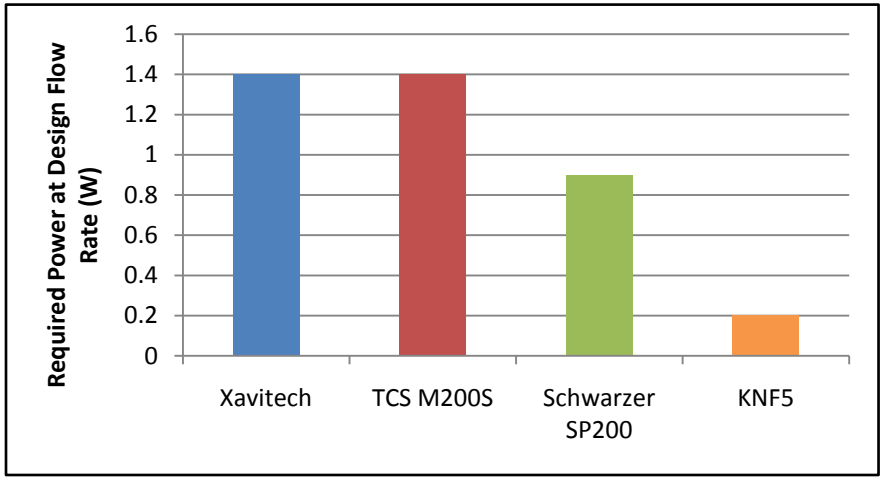
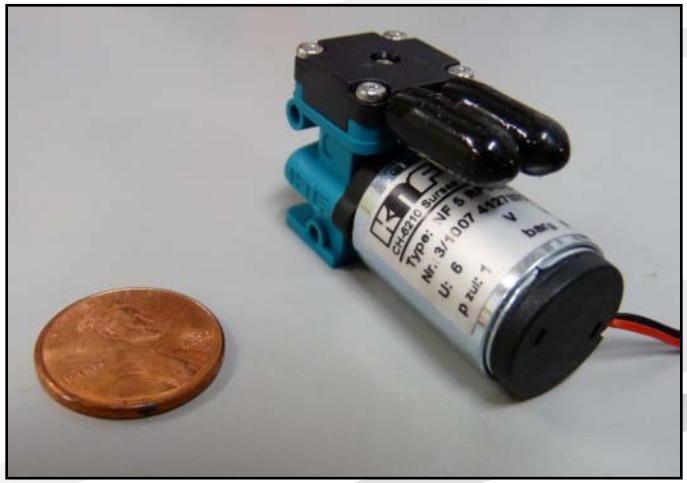
Technical Accomplishments:

Anode Recirculation Pump

- Six different recirculation pumps have been tested.
- The KNF5 has been selected at the recirculation pump – significant reduction in parasitic power.
- Long term test plan underway.





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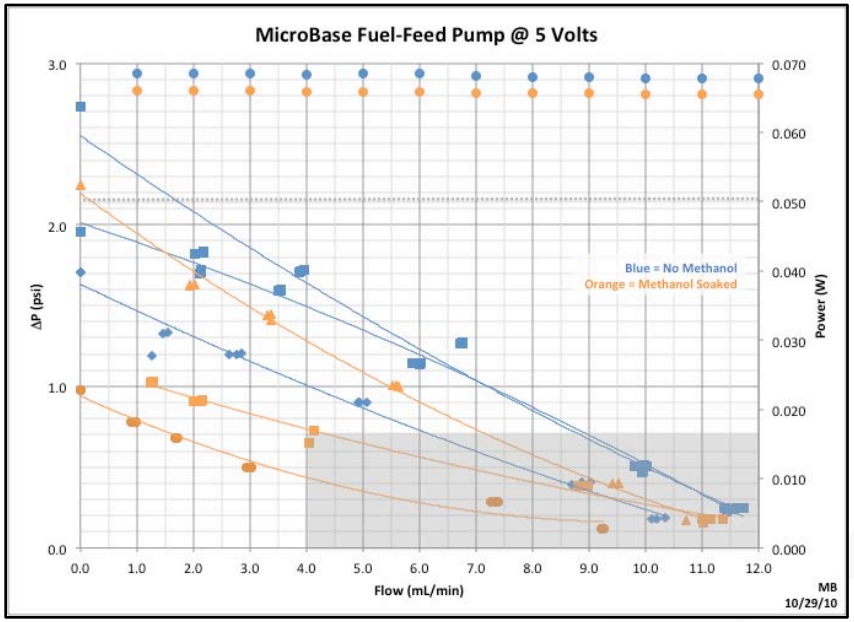
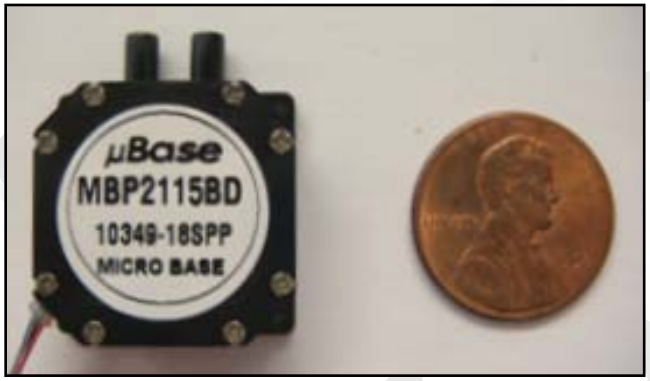
Technical Accomplishments

Methanol Injection Pump

- The Microbase MBP2115BD is one of the few fuel injection pumps that meet the system requirements.
- Methanol durability and manufacturing repeatability testing is underway.



Grey area indicates system load curve.



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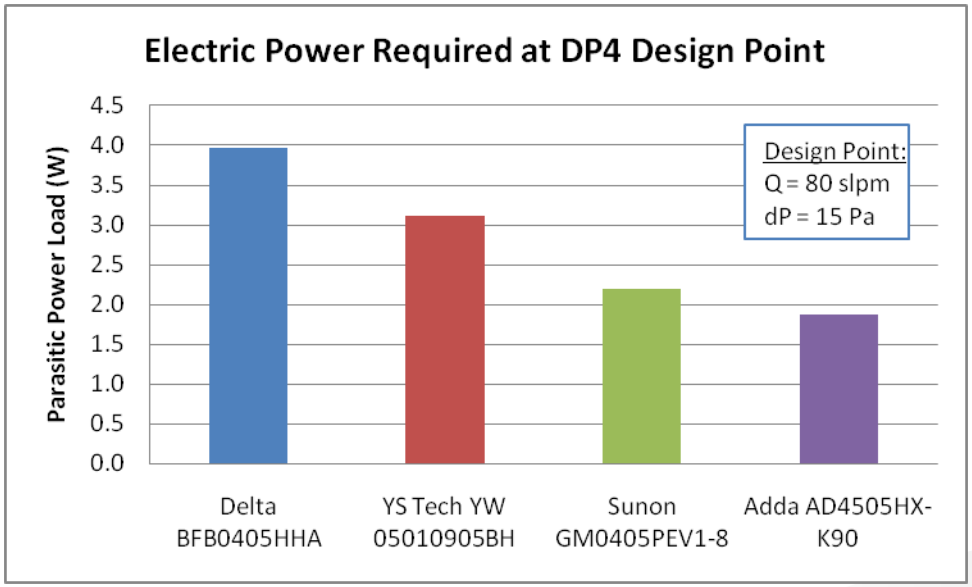
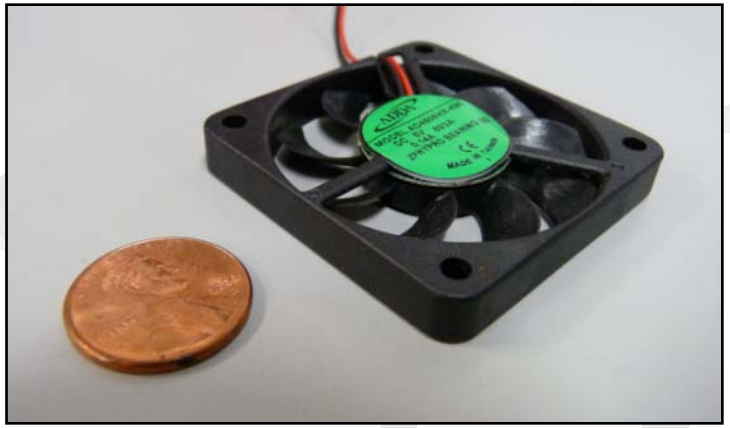
Technical Accomplishments:

Cathode Reactant/Cooling Fan

- The ADDA AD4505HX-K90 has been selected as the cathode supply fan from dozens of fans tested and evaluated.
- The ADDA fans have completed over 2000 hours of operation and still meet design point requirements.

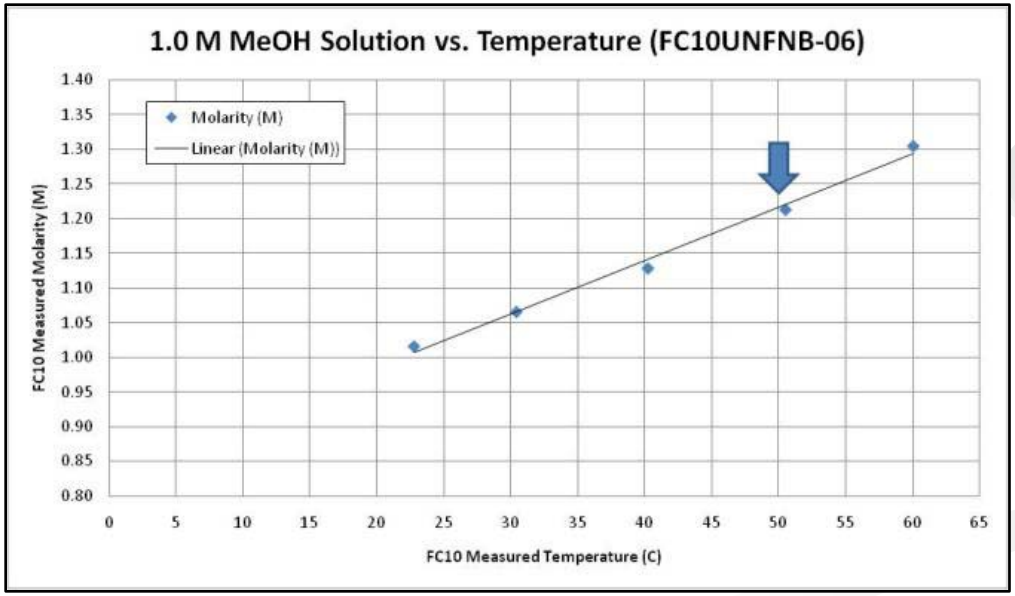




Technical Accomplishments:

Methanol Sensor

- The ISSYS FC-10 density meter is the selected methanol sensor.
- Temperature compensation added to reduce chances of fuel starvation.
- ISSYS FC-10 sensor is not optimized for the application (size, weight, and cost).
- Three alternative methanol sensing technologies were identified and two are still under active investigation (Spreeta and JRC).



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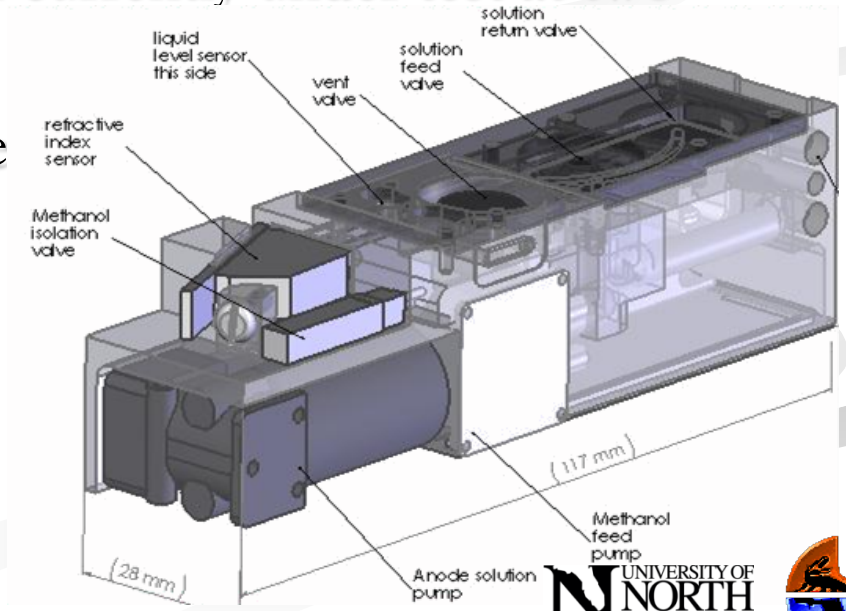
Technical Accomplishments:

System Engineering

- Concept design review held in January - Mechanical design nearly complete
- Integrated prototypes (adaption of brassboard designs) are currently in the manufacturing and assembly phase.
- Brassboard (unpackaged) system currently under test at two locations
- Packaging effort nearly complete
- Hybrid strategy study underway
  - Battery size and type selected and in talks underway with "packager"



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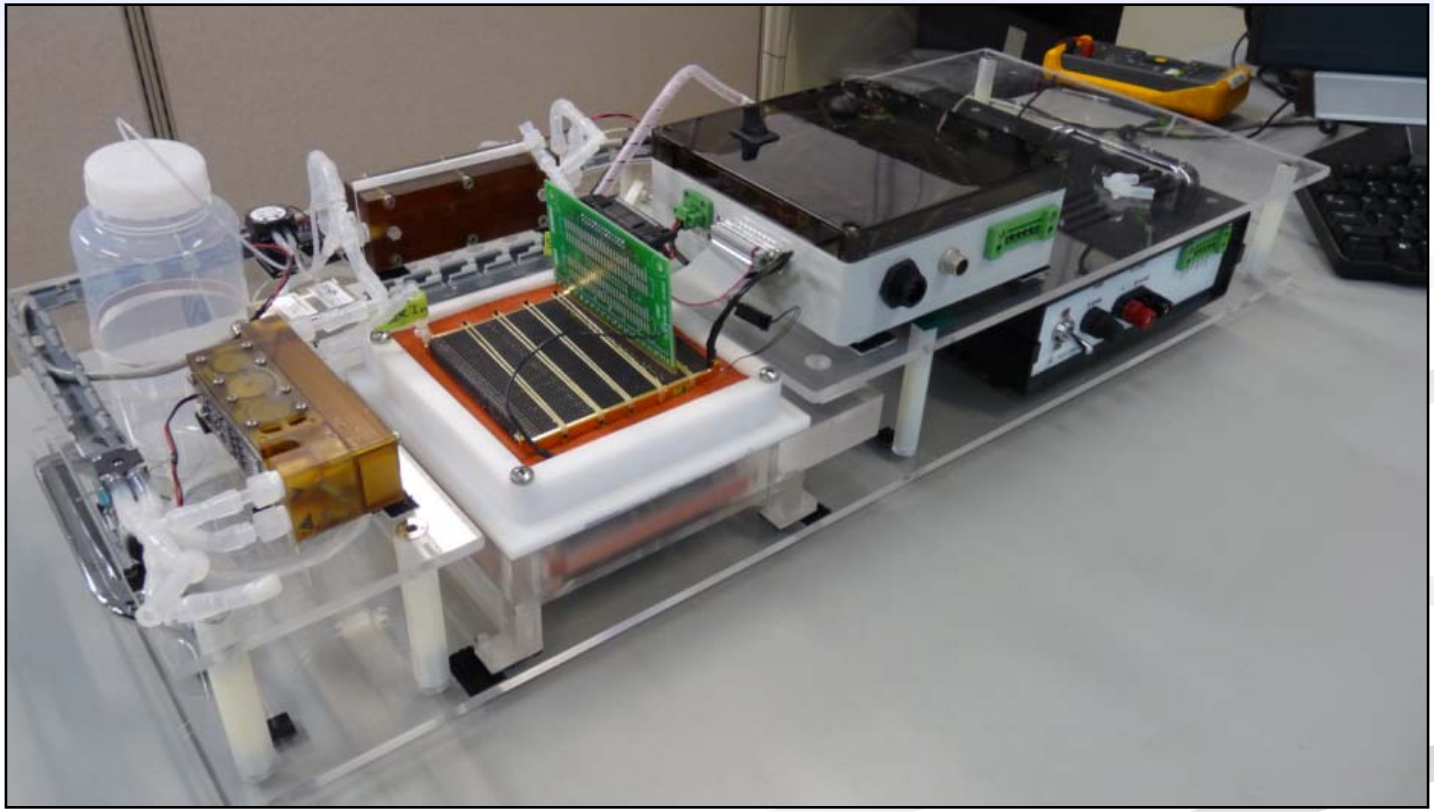
Technical Accomplishments:

System Engineering: Brassboard (Unpackaged System)

- Completion and operation of three brassboards to date.



Each brassboard has over 500 hours of operation.

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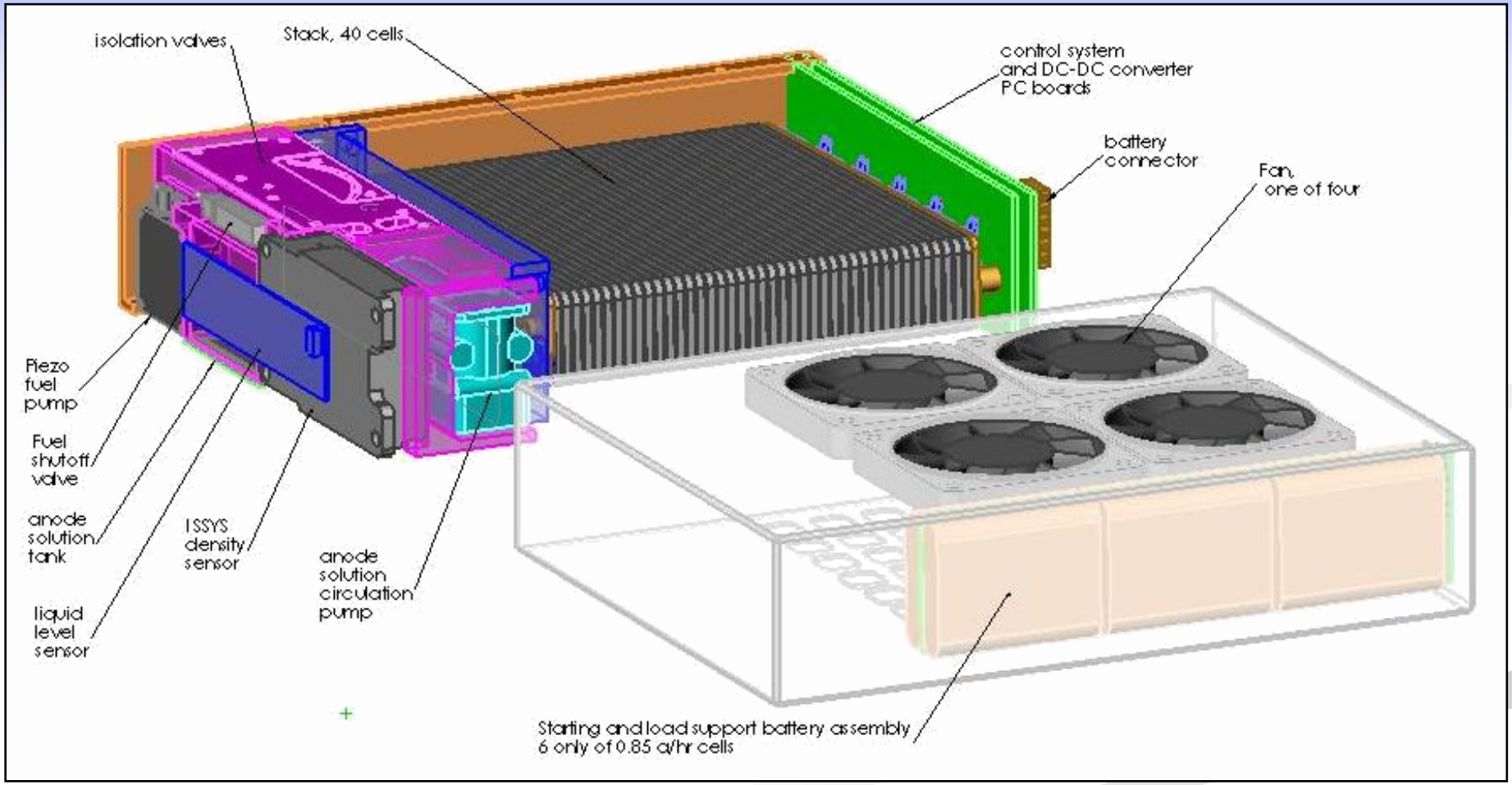
Technical Accomplishments:

System Engineering: Packaged System



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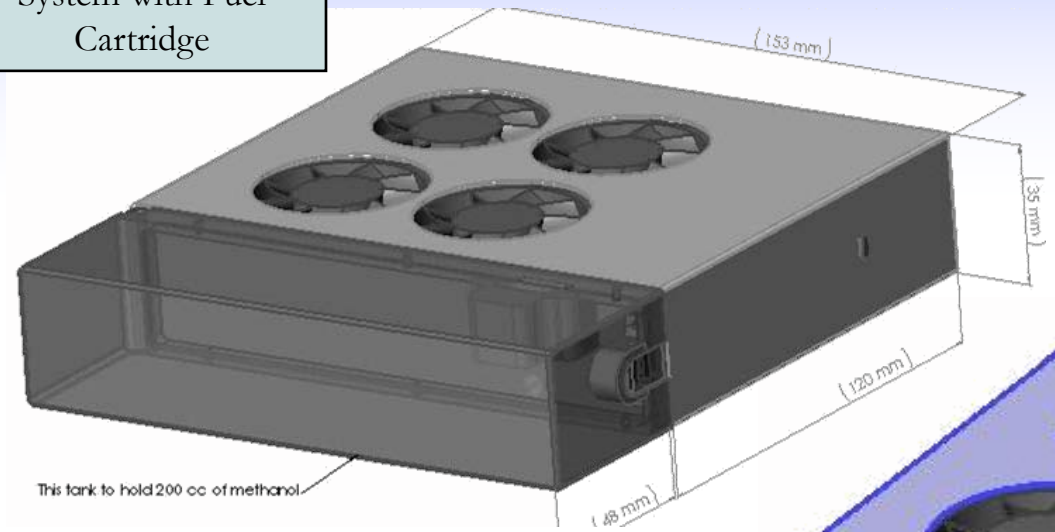
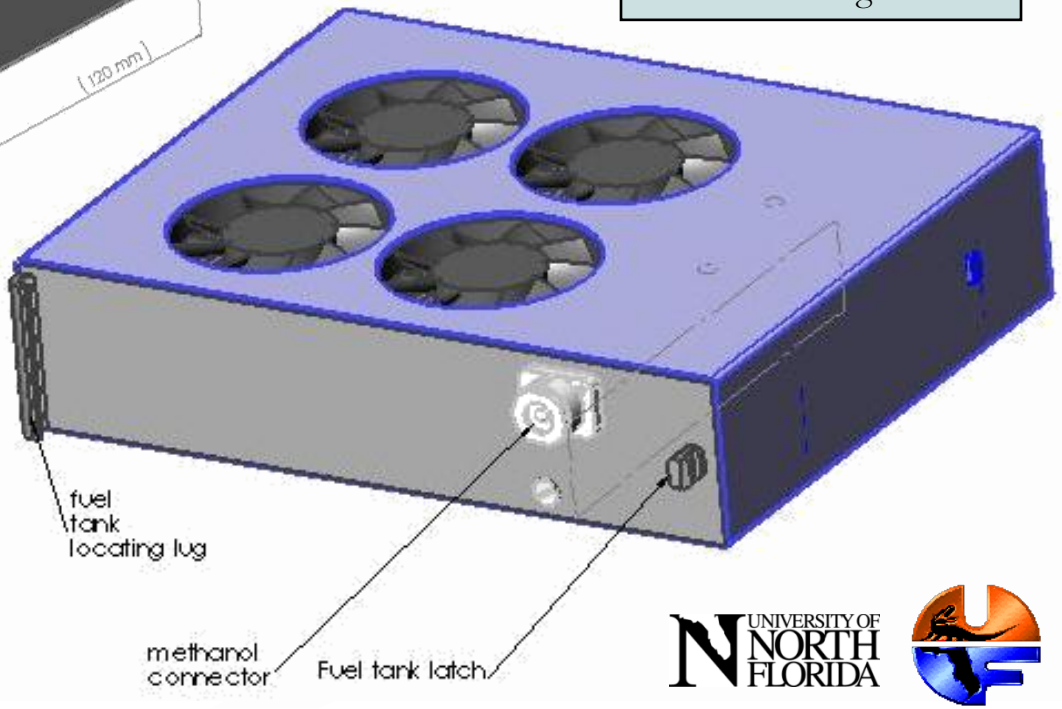
Technical Accomplishments:

System Engineering: Packaged System with Fuel Cartridge

System with Fuel Cartridge



System without Fuel Cartridge



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Technical Accomplishments:

Control System Development

- Use of multiple brassboards at multiple locations
  - Significant improvement in control strategy & stability.
  - Accelerated troubleshooting of control code.
- Startup & shutdown algorithms are being improved to accommodate various system volumes (i.e. tank size)
- Introduction of maximum water generation mode improves liquid management.
- Validation of dynamic model with DP4 system data.

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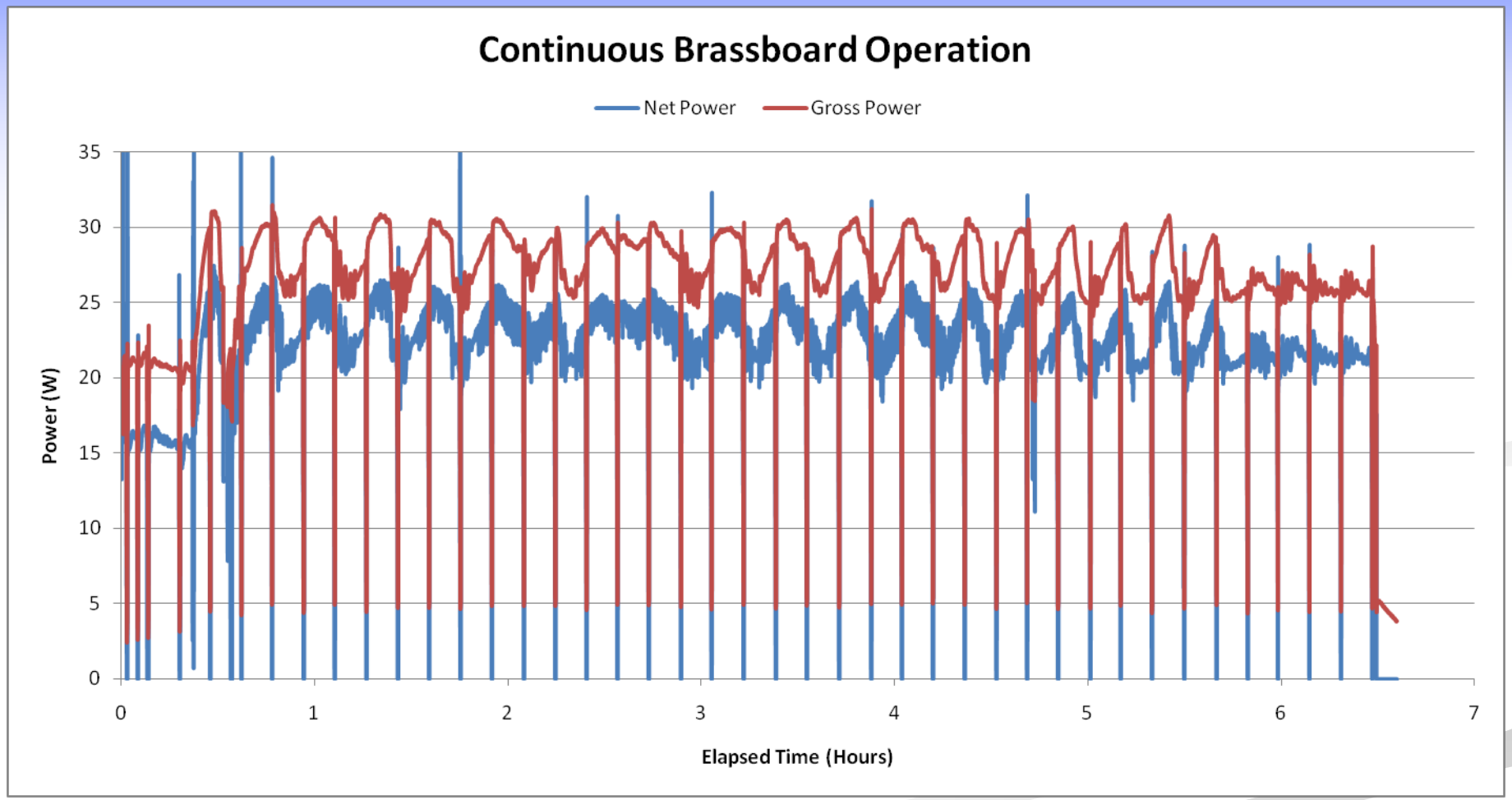
Technical Accomplishments:

System Validation Testing



Consistent, reliable brassboard operation.

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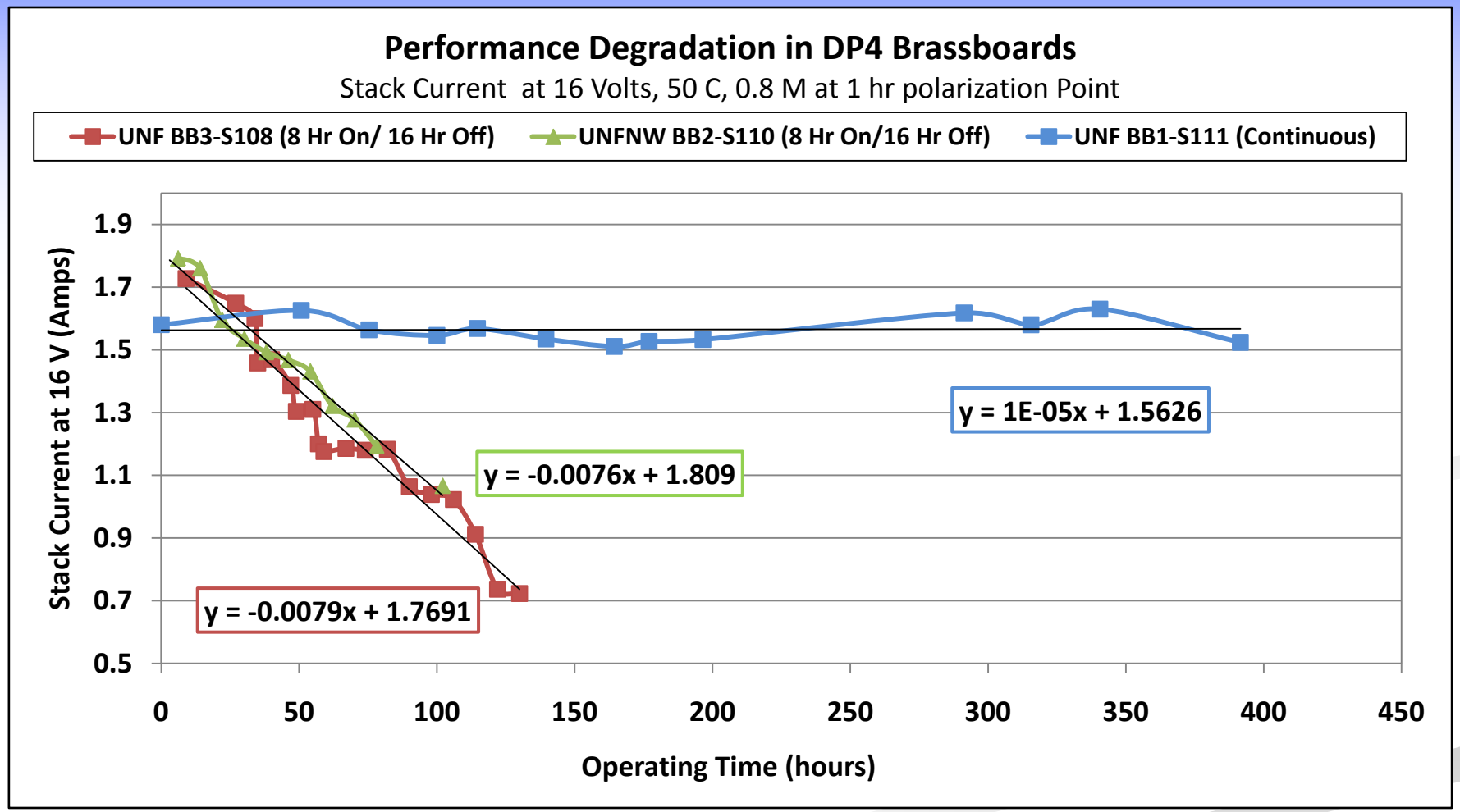
Technical Accomplishments:

System Validation Testing



Brassboard performance degradation two orders of magnitude less with continuous operation. Extensive effort underway in conjunction with the DOE Topic 5A project to identify and mitigate root cause.

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Collaborations

- University of Florida (Academic)
  - Dr. Bill Lear leads the effort to develop critical components including the fuel pump, the recirculation pump, and the CO_2 removal membrane
  - Dr. Oscar Crissale leads the effort to develop the overall control strategy
- The DOE funded project (UNF Prime) *New MEA Materials for Improved DMFC Performance, Durability, and Cost* includes the following collaborators:
  - University of Florida (Academic): Focus on manufacturability and advanced catalysis
  - Johnson Matthey (Industry): Integration of commercial processes into the MEA manufacturing
  - Northeastern University (Academic): Advanced catalysis focused on ultra-stable ruthenium catalyst

The University of North Florida (Prime) and the University of Florida also collaborate on a U.S. Army CERDEC funded project to develop a militarized version of the DMFC laptop power supply

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Proposed Future Work

FY 11

- Complete development of advanced control strategies.
- Improve control code for mitigation of system warnings (low methanol concentration, high stack temperature, etc.).
- Integrate components and sub-systems into packaged unit.
- Extensive system testing including performance, robustness, and lifetime.

- **KEY Milestone**: Compare system attributes (power density, expected lifetime, etc.) versus milestones/DOE requirements.

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Project Summary

- **Project Relevance:** The novel passive water recovery MEA technology allows for simplified balance-of-plant which results in a DMFC power supply approaching the DOE 2010 Technical targets.
- **Approach:** Cascade-down design requirements to each component resulting in a robust design. Integrate the balance-of plant with the optimized passive water recovery MEA.
- **Technical Accomplishments:** Component performance testing complete. Brassboard fabrication and testing nearly complete. Packaged system design nearly complete.
- **Collaborations:** Technical expertise at UF focused on component development and robust control system.
- **Proposed Future Work:** Packaged system fabrication and testing.

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